NASA TECH BRIEF

Analysis of Annular Combustors

The problem:

The cut-and-try methods generally used to design combustion chambers have been giving way in recent years to a more systematic approach based on analysis and correlation of experimental data. This approach is potentially capable of substantially reducing development time and expense while improving combustor performance. While the analytical methods and correlations presently available are crude in many respects, they are nonetheless sufficiently complex that computers can effectively be used in their solution. Therefore, it is desirable to devise such a systematic approach to the design and analysis of gas turbine combustors.

The solution:

A computer program has been developed for the analysis of fluid flow, combustion, and heat transfer in annular and rectangular combustors with diffusers, making use of currently available analytical methods and correlations.

How it's done:

The analysis is divided into three main parts:

1. Performance of the diffuser.
2. Air-flow, pressure, and temperature distributions both in and around the combustion liner, including calculation of the combustor total-pressure loss.
3. Heat transfer and the calculation of combustion linear-wall temperature distribution.

The diffuser subprogram calculates diffuser performance parameters (effectiveness and pressure-recovery coefficient) and diffuser outlet flow conditions for a prescribed geometry and inlet flow conditions.

Three computing options are available:

1. The streamtube method, which subdivides each diffusing passage into a number of streamtubes, computing flow conditions in each. The development of the boundary layers at the passage walls is followed, and the boundary-layer separation is predicted.
2. The empirical-data method, in which diffuser effectiveness is obtained from correlations tabulated within the program or alternatively from data supplied directly by the user.
3. The mixing-equation method, a relatively crude method that considers the pressure-loss mechanisms in the diffusing passage as a whole.

The air-flow subprogram calculates flow conditions in the flame tube and annuli of the combustor, including the total-pressure loss. The flow of air into the flame tube through holes and cooling slots is found from experimentally measured discharge coefficients tabulated within the program as functions of pressure drop across the hole, for a large number of hole geometries. The mixing of the jets and wall-cooling air into the flame-tube gases is computed from any one of three jet-mixing correlations, to be selected by the user.

The heat-transfer subprogram computes the axial distribution of temperature along the flame-tube walls. The heat-flux components that are considered may include several or all of the following, depending upon the program options specified by the user:

1. Convection from the flame-tube gases.
2. Convection to the annulus air.
3. Radiation from the flame.
4. Radiation to the outer casing.
5. Radiation interchange between the flame-tube walls.

(continued overleaf)

6. Longitudinal conduction along the flame-tube wall.
7. Heat transfer to transpiring air for porous walls.

For the calculation of radiation, five flame-luminosity correlations are included, two for nonluminous and three for luminous flames; one-dimensional (purely radial) or two-dimensional (radial-axial) radiation-calculation options may be selected.

Notes:

1. This program is written in Fortran IV for use on the IBM 7094/7044 Direct Coupled System.
2. This program is useful for the steady-state analysis of axial-flow gas-turbine combustor designs and for the design of high performance annular combustors.
3. Complete details of this program are contained in "Computer Program for the Analysis of Annular Combustors—Volume I: Calculation Procedures" by Northern Research and Engineering Corporaation, NASA-CR-72374, January 29, 1968, and "Computer Program for the Analysis of Annular Combustors. Volume II: Operating Manual" by Northern Research and Engineering Corporation, NASA-CR-72375, January 29, 1968, which are available from:

   COSMIC
   Computer Center
   University of Georgia
   Athens, Georgia 30601
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No patent action is contemplated by NASA.

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